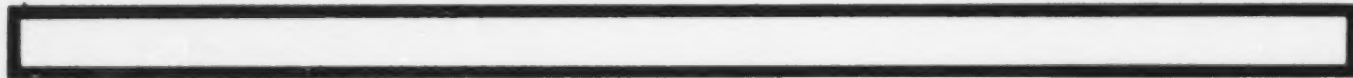


PB86-211919

Long-Term Effects of Municipal Solid
Waste Leachate on Landfill Liners

(U.S.) Environmental Protection Agency
Cincinnati, OH

Jun 86



U.S. Department of Commerce
National Technical Information Service

NTIS

EPA/600/D-86/124
June 1986

LONG-TERM EFFECTS OF MUNICIPAL* SOLID WASTE LEACHATE
ON LANDFILL LINERS

by

Robert E. Landreth

HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OH 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA/600/D-86/124	2.	3. RECIPIENT'S ACCESSION NO. PB86 211919/AS
4. TITLE AND SUBTITLE LONG-TERM EFFECTS OF MUNICIPAL SOLID WASTE LEACHATE ON LANDFILL LINERS		5. REPORT DATE June 1986
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Robert E. Landreth		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency, HWERL, LPCD 26 West St. Clair Street Cincinnati, OH 45268		10. PROGRAM ELEMENT NO. BRD1A
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Hazardous Waste Engineering Research Lab--Cin, OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Symposium Paper
		14. SPONSORING AGENCY CODE EPA/600/14
15. SUPPLEMENTARY NOTES Contact: Robert E. Landreth 513/569-7836		
16. ABSTRACT A study was conducted to determine the long-term effects of municipal solid waste leachate on wide variety of materials that could be used as landfill liners. To determine the effective service lives of these materials when placed in a prolonged contact with leachate or landfill conditions, 65 materials were subjected to at least one of seven different exposure tests. These materials included four admixes, two asphaltic membranes, 50 commercial polymeric membrane liners, and nine miscellaneous materials. Types of exposure tests included simulated landfill exposures, immersion tests in tanks containing leachate and water, and pouch tests. Results indicate that liners for municipal solid waste refuse are available to contain any leachate that may be generated. Field Studies suggest that laboratory tests can be used to predict chemical resistance.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 17
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Long-Term Effects of Municipal Solid Waste Leachate on Landfill Liners

Robert E. Landreth

A study was conducted to determine the long-term effects of municipal solid waste leachate on wide variety of materials that could be used as landfill liners. To determine the effective service lives of these materials when placed in a prolonged contact with leachate or landfill conditions, 65 materials were subjected to at least one of seven different exposure tests. These materials included four admixes, two asphaltic membranes, 50 commercial polymeric membrane liners, and nine miscellaneous materials. Types of exposure tests included simulated landfill exposures, immersion tests in tanks containing leachate and water, and pouch tests.

Results indicate that liners for municipal solid waste refuse are available to contain any leachate that may be generated. Field Studies suggest that laboratory tests can be used to predict chemical resistance.

INTRODUCTION

Leachates generated by water percolating through sanitary landfills can seriously degrade surface waters and groundwaters, particularly in areas subject to high humidity and rainfall. Lining landfills with materials of very low permeability could provide a long-term solution to the problem of leachate pollution and could also make previously unacceptable sites usable as landfills. The U.S. Environmental Protection Agency (EPA) Hazardous Waste Engineering Research Laboratory initiated a program to evaluate the potential of various lining materials for controlling the movement of leachate from landfills by examining their properties after different types of exposure to municipal solid waste (MSW) leachate.

Little was known about the long-term durability of lining materials in contact with MSW leachate when this project began in 1973. The scope of the work and the objectives were updated periodically to reflect the rapidly changing liner technology and to evaluate new liner materials. The principal objectives of the project were as follows:

1. To determine the long-term effects of MSW leachate on a wide variety of materials that could be used as landfill liners,
2. To determine the effective service lives of these materials when in prolonged contact with leachate or landfill conditions,
3. To develop laboratory tests for assessing the properties of membrane liners under simulated field conditions,
4. To generate a useful data base for MSW landfill liners, and
5. To analyze costs associated with the use of landfill liners.

METHODS AND MATERIALS

In the course of this study, 65 materials were subjected to at least one of seven different exposure tests. These materials included four admix materials, two asphaltic membranes, 50 commercial polymeric membrane liners, and nine miscellaneous materials. The number and types of liners and exposures are summarized in Table 1.

The exposure tests involved placing liner samples in (1) landfill simulators containing 8 ft of compacted, shredded urban refuse, (2) immersion tanks containing MSW leachate or water, and (3) polybutylene bags containing deionized water. (The latter test was known as the pouch test because membrane samples were formed into pouches before immersion and filled with leachate or 5% salt solution.)

Exposure Tests In Landfill Simulators

Exposure tests in landfill simulators were performed on 12 different primary samples sealed into the bases of the simulators and on 40 different secondary samples buried in the sand above the primary liners (see Table 1). Types of materials used are listed in Table 2.

The simulators in which the liners were exposed and the leachate was generated consisted of 10-ft columns containing 8 ft of compacted, shredded refuse (see Figure 1). The primary liners were sealed into the simulator bases with a rapid-set epoxy resin to prevent the leachate from bypassing the liners. Thus any seepage through the liner could be measured. A hydraulic head of 1 ft of leachate was maintained on the liners, and any excess leachate was collected continuously.

The leachate was generated by percolating 25 in. of tap water per year through the 8-ft column of ground refuse in each of the simulators. Leachate quality for all 24 simulators was in the normal range for leachate generated by full-scale landfills.

Liner properties were measured during the course of the exposure to determine changes. All specimens in the simulators were tested before (zero exposure) and after 12 and 56 months of exposure. The asphaltic and the secondary polymeric membranes were also tested before and after 13 and 43 months, and miscellaneous secondary samples were also tested after 43 months.

The membrane liners were tested for adsorption of leachate and for changes in tensile strength, tear resistance, puncture resistance, seam strength, and permeability. The other materials were tested for appropriate properties.

Because available information indicated that the seams in polymeric membrane liners were the most likely source of liner failure, seams were incorporated into as many of the test specimens as possible. Factory

Table 1. Scope of Exposure Tests

Type of exposure	Number of liners	Type of liner material	Length of exposure (months)
Primary, in simulators	6	Polymeric membrane	12,56
	4	Admix	12,56
	2	Asphaltic membrane	12,43,56
Buried, in simulators	31	Polymeric membrane	12,13,43,56
	9	Miscellaneous materials	12,43,56
Immersion, in tanks	28	Polymeric membrane	8,19,31
Pouch test:			
With leachate	14	Polymeric membrane	11-40
With NaCl solution	12	Polymeric membrane	10-38
Water absorption (ASTM D570):			
At room temperature	11	Polymeric membrane	43
At 70°C	11	Polymeric membrane	43

Table 2. Materials Used in Landfill Simulator Exposure Tests

<u>Primary liner materials</u>	<u>Secondary liner materials</u>
Admixes:	Polymeric membranes
Paving asphalt concrete	Butyl rubber
Hydraulic asphalt concrete	Chlorinated polyethylene
Soil asphalt	Chlorosulfonated polyethylene
Soil cement	Elasticized polyolefin
Asphaltic membranes:	Neoprene
Bituminous seal	Polybutylene
Emulsified asphalt on nonwoven fabric	Polyester elastomer
Flexible polymeric membranes:	Low-density polyethylene
Butyl rubber	High-density polyethylene
Chlorosulfonated polyethylene	Polyvinyl chloride
Ethylene propylene rubber	Miscellaneous materials:
Low-density polyethylene	Asphalt roofing felt
Polyvinyl chloride	Polypropylene
	Thermoplastic rubbers
	Commercial gasket materials
	based on natural rubber
	Styrene-butadiene rubber
	Urethane
	Neoprene

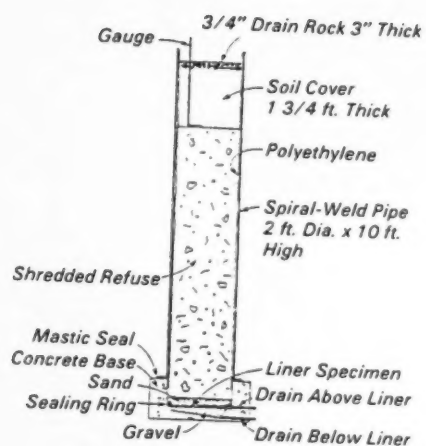


Figure 1. Landfill simulator used to evaluate liner materials exposed to sanitary landfill leachate.

seams or seams made according to the manufacturer's recommended practices were used for all primary liner specimens in the landfill simulators. Adhesives supplied by the manufacturer were used in most cases. Test joints were also incorporated into the strips buried in the sand above the primary liners. Tests were performed on some systems suggested by manufacturers of other liners based on the same polymer, even though they had not been recommended by the manufacturer of the specific material.

Exposure Tests In Immersion Tanks Containing Leachate and Water

To investigate the effects of immersion in MSW leachate, three sets of slab specimens of 28 different polymeric sheetings (Table 3) were immersed in MSW leachate generated in the simulators. Because MSW leachate is principally water (which by itself can be aggressive to many materials), water absorption tests were also conducted by immersing 11 membrane liners in water for up to 186 weeks, both at room temperature and at 70°C.

Similar immersion tests were attempted with admix specimens, but in their unconfined state, they crumbled apart when hung in the leachate.

The immersion system was designed to allow blended leachate from the 12 simulators to flow slowly through a series of high-density polyethylene tanks in which the membrane-slab specimens were hung (Figure 2). This arrangement was acceptable because polyethylene has low permeability to air, and only small changes in leachate composition were observed when the leachate was stored in these containers for a month at room temperature. Furthermore, this design exposed more specimens easily, exposed all specimens to the same leachate, and required considerably less time to construct and monitor than individual tanks or bags attached to the simulators. A Masterflex* pump delivered leachate at the rate of 14 ml/min through the tanks, recirculating the supply of leachate in about 12 days.

Three sets of the 28 membranes were immersed in the leachate so that one set could be removed after each exposure period (8, 19, and 31 months). The 8- by 10-in. specimens were hung vertically 0.92 in. apart in the tanks (Figure 2).

Pouch Test

The pouch test involved fabricating a small pouch from the membrane liner, filling it with test fluid (such as leachate), and placing it in a deionized water solution in a polybutylene bag (Figure 3). This test offers the opportunity of exposing liner materials to two fluids at the same time--as would be the case in a landfill where leachate would contact one side of the membrane and groundwater the other.

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Table 3. Liners immersed in MSW leachate

Type of polymer	Number of different sheetings immersed
Butyl rubber (IIR)	1
Chlorinated polyethylene (CPE)	3
Chlorosulfonated polyethylene (CSPE)	3
Elasticized polyolefin (ELPO)	1
Ethylene propylene rubber (EPDM)	5
Neoprene (CR)	4
Polybutylene (PB)	1
Polyester elastomer	1
Low-density polyethylene (LDPE)	1
Polyvinyl chloride (PVC)	7
PVC and pitch	<u>1</u>
	28

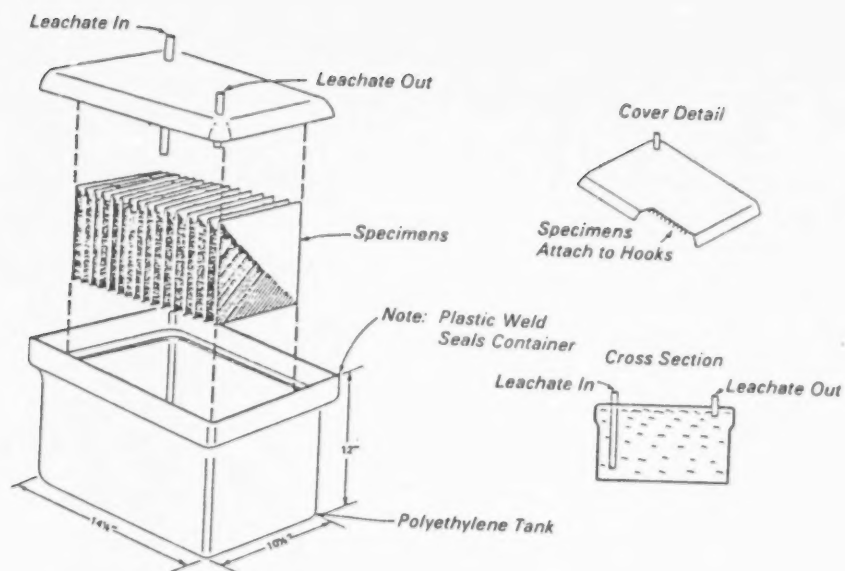


Figure 2. Individual polyethylene immersion tank showing method of holding specimens and the inlet and outlet for the leachate.

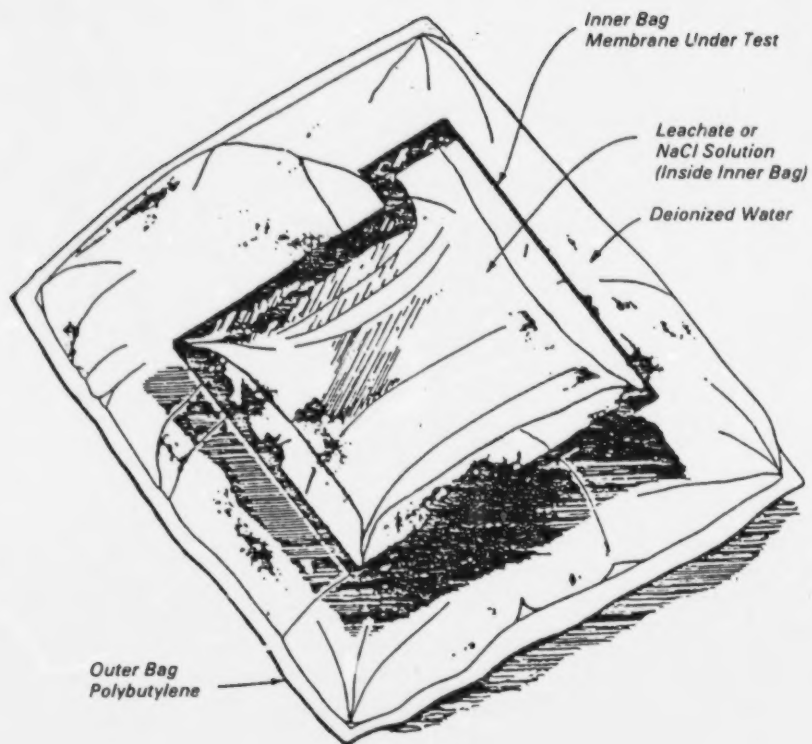


Figure 3. Schematic of pouch assembly showing inner bag made of membrane material under test. The inner bag is filled with leachate or 5% salt solution and sealed at the neck. The outer polybutylene bag, which can be easily opened, is filled with deionized water. The water in the outer bag is monitored for pH and conductivity, the inner bag is monitored for weight change.

The pouch test was used primarily to test permeability, but other properties of the membranes were also tested after exposure. Two fluids were tested in the pouches: One set of pouches was filled with leachates, and another set was filled with a 5% aqueous solution of sodium chloride. The latter solution was of known composition and was therefore used to measure the movement of ions and to set up a known concentration differential across the membrane.

The liner materials used in these pouch tests included chlorinated polyethylene, chlorosulfonated polyethylene, elasticized polyolefin, polyester elastomer, and polyvinyl chloride (three different formulations).

The following tests were performed during the exposure of these pouches:

1. The deionized water surrounding the leachate-containing pouches was tested periodically for pH, conductivity, and the odor of butyric acid (from the leachate).
2. The pouches containing the test fluid (leachate or salt solution) were removed periodically from the deionized water and weighed.

Long-Term Field Studies

The selection of an appropriate liner for use in containing MSW refuse and leachate is only the initial step in obtaining a successful landfill. This study has demonstrated that commercially available materials will provide containment for at least 58 months. However, longer containment periods are required to meet existing criteria and to minimize risks to the public health and safety and to the environment.

The Agency has continuously searched for sites being decommissioned or relined to obtain liner samples that have been exposed for long periods. The program has met with limited success. One MSW refuse site was the Agency's Boone County Field Site in Kentucky. This site is important because clay, reinforced CSPE, LDPE, and CPE liner materials were used in the liner systems. The landfill was filled with urban MSW refuse. Leachate quality was in the normal range for MSW landfills. The first test cell was constructed with the CSPE liner placed over natural soil and with clay placed on top of the CSPE liner. The LDPE liner was placed around the leachate collection trench.

Construction Quality Assurance

The final steps in developing a successful landfill involve ensuring that the final product is as it was designed. A complete construction quality assurance plan will help obtain the best possible liner installation, among other components. Included in this plan are preconstruction, construction, and post-construction activities.

Preconstruction activities include, for example, manufacturing the FML to ensure that the material is of good quality, meets the chemical resistance criteria, and meets specifications. Inclusion of FML transportation and storage in the quality assurance plan helps to alleviate potential problems with stripping and storing materials in extreme temperatures, puncturing the liners during packaging, loading, or unloading, and protecting them from weather and vandals at the site.

Construction activities include the actual FML placement according to the designer's layout, FML seaming (which should include both destructive and non-destructive evaluation), attention to anchors and seals around penetrations and upper bedding placement. These activities are only briefly mentioned and should not be taken lightly. Very detailed plans developed at the beginning and understood and agreed to by all parties will speed the installation process and help ensure a liner that meets the design specifications.

Post construction activities include a final visual inspection before placing the upper bedding layer. Any damaged area should be repaired. In selected situations, it may be necessary to check the liner integrity by filling or partially filling the facility with water and checking for leaks. The leachate collection system, tracer dyes, and electrical resistivity techniques are available to help locate potential liner leaks.

RESULTS

Effects of Leachate Exposure on Liner Properties

Polymers--

Exposing a wide range of polymeric membranes to a typical MSW leachate in the landfill simulators for up to 56 months produced only limited changes in their properties. Only one type of liner--the polyester elastomer--showed a potentially significant loss of properties.

Some of the polymeric membrane liners exhibited significant swelling during the exposure periods and losses in tensile strength and other physical properties. Swelling of membranes in leachate was greater than that in water, which indicates the importance of the organic components of the leachate with respect to the swelling of polymeric materials.

Among the polymeric lining materials, the partially crystalline thermoplastic materials showed the least amount of swell and the fewest changes in properties.

Generic classification of polymeric materials by polymer type is not sufficient to predict the performance of a given liner. Variation in grade and the presence of other compounding ingredients affect the performance of a polymeric composition. Variations also arise with the use of fabric reinforcements.

Asphaltic Materials--

The asphaltic materials, whether concretes or membranes, did exhibit some deficiencies after leachate exposure that might ultimately affect their serviceability as linings for MSW waste disposal facilities. The concretes tended to lose strength, and the membranes absorbed leachate and lost ductility and elongation. The asphaltic membranes that had been exposed for 56 months showed areas that had lost ductility and

elongation and had become "cheesy." On drying, the cheesy section of the asphalt returned to normal and showed very little or no change in basic properties compared with the original asphalt.

Soil Cement-

The properties of the soil cement specimen tended to improve during exposure. The specimen was very small, however (2 ft in diameter).

Effects of Leachate Exposure on Seams

The seaming of membrane liners by heat or welding with solvents or bodied solvents that are solutions of the liner compound appears to yield seams with the highest integrity. Adhesives that differ in composition from the liner introduce a new composition that must be assessed for compatibility in a given waste stream. Results also showed the values could vary greatly as a result of differing quality of workmanship.

The low-temperature vulcanizing adhesives, which are required in the seaming of vulcanized or crosslinked sheetings, generally yielded lower seam strength values; but in some cases, they showed increases, probably because of additional cure. A significant problem with this type of adhesive system arises over time because of their fewer crosslinks compared with the vulcanized sheeting. That condition can cause the adhesive to swell considerably more during exposure and thus lose strength.

Long-Term Field Studies at Boone County, Kentucky

Chemical tests indicated that nearly all of the leachate was contained above the clay liner. No visual signs of cracking, channeling, or unusual changes in texture or consistency were noted in any of the excavations.

CSPE liner samples had been in contact with dilute leachate for 9 years; they had imprints of gravel and were swollen and soft as could be predicted by laboratory tests. Substantial amounts of leachate had been absorbed by the CSPE samples. The physical properties of all these samples appeared to be approximately the same, and values all appeared to be relatively normal for a CSPE material.

The LDPE film was clear after the surface stain was washed off, and it appeared to be unaffected by its 9 years of exposure to the full-strength leachate. The sample showed little swelling, and its properties were normal for a 6- to 7-mil LDPE. No punctures or tears of the material were observed during sample removal.

The second test cell containing the CPE liner was constructed by placing the liner over a sand bed and covering it with a protective layer of sand.

Analysis of the layers of sand above and below this liner indicated that it had contained the leachate. The CPE liner samples were stiff and leathery and showed significant adsorption of leachate. Nonetheless, their properties were relatively good. Two samples of CPE liner that

had been exposed only to weather and not to leachate were significantly higher in tensile strength, moduli, and puncture resistance compared with the leachate-exposed samples.

Again, these results appear to confirm laboratory tests for these types of materials.

Other samples exposed to municipal wastewater sludge and hazardous wastes in the field have shown good agreement with controlled laboratory tests. Though insufficient data exist to develop a predictive model, laboratory tests can be used to predict chemical resistance. Additional field samples would allow the development of predictive models and a better understanding of service life.

CONCLUSIONS

Liners for municipal solid waste refuse can and are being designed, constructed, and operated in an environmentally acceptable manner. Liner materials based on site-specific needs are available to contain any leachate that may be generated. Field studies suggest that laboratory tests can be used to predict chemical resistance. A complete construction quality assurance plan will help ensure that the as-built facility is as-designed.

REFERENCES

1. "Liner Materials Exposed to Municipal Solid Waste Leachate," Henry E. Haxo, Jr., Richard M. White, Paul D. Haxo, and Michael A. Fong, Matrecon, Inc., February 1982, EPA 600/2-82-097, PB 83-147801.
2. "Field Assessment of Site Closure, Boone County, Kentucky," Emcon Associates, September 1983, EPA 600/2-83-058, PB 83-251629.
3. "Construction Quality Assurance for Hazardous Waste Land Disposal Facilities - Public Comment Draft," C. M. Northeim and R. S. Truesdale, Research Triangle Institute, October 1985, EPA 530-SW-85-021.